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Expoziţia Internaţională Specializată
INFOINVENT
22-24 noiembrie 2023
Ediția a XVIII-a

Formaldehyde Chemiresistive Sensor

Romanian Patent Application A00358, RO, OSIM, 10.07.2023

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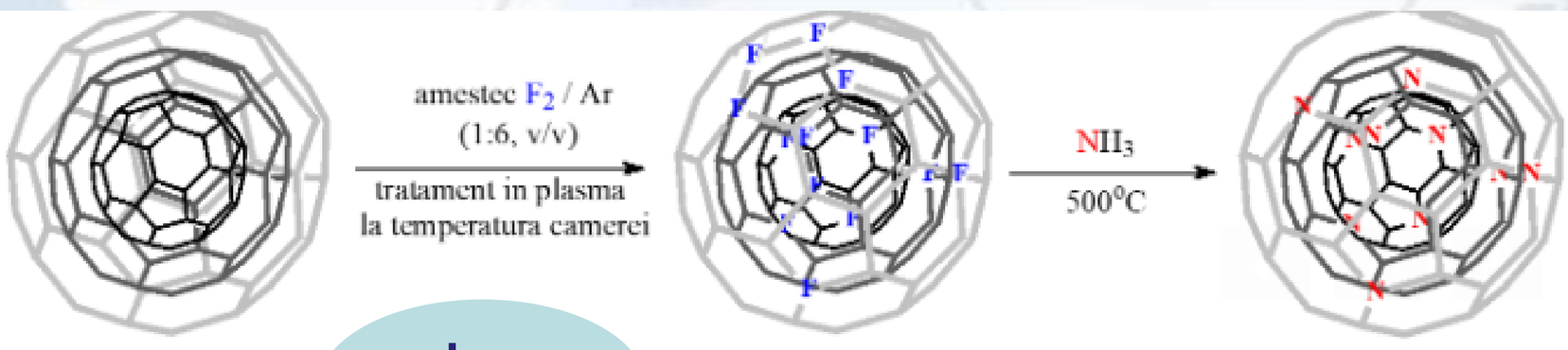
Field of Invention

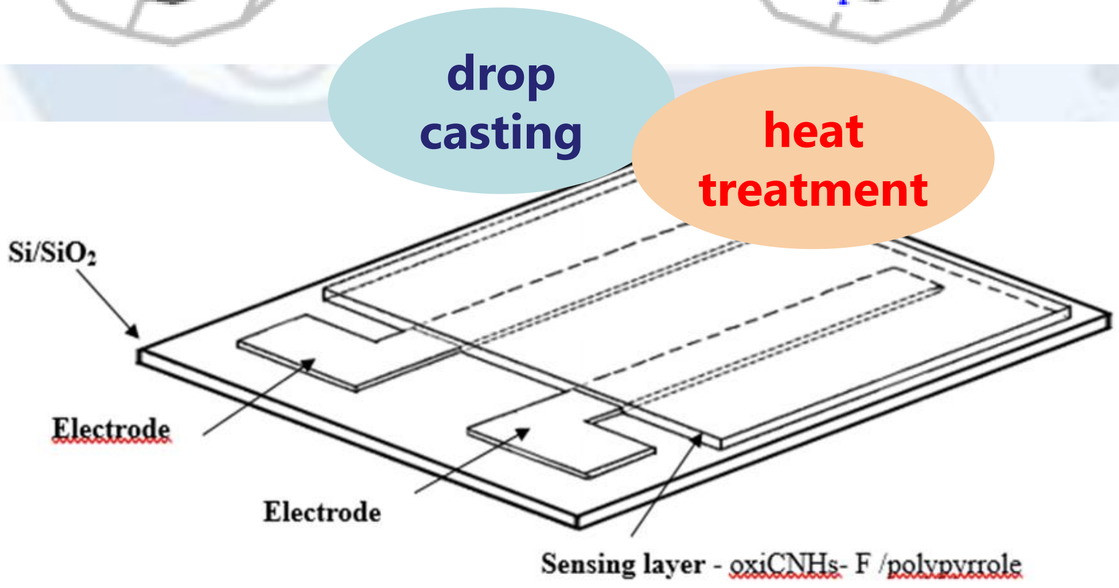
Formaldehyde is a volatile organic substance (VOC), flammable, colorless, with a strong smell, and is a valuable intermediate in the chemical industry, light industry, etc. Formaldehyde is used as a raw material in the synthesis of compounds such as phenol-formaldehyde resins, melamine resins, 1,4 butane diol, methylene diisocyanate, etc. Also, it is used in household products such as antiseptics, medicines, and cosmetics, as well as as a preservative in anatomical preparations.

Original approach

The sensitive film described in this invention, which is used to obtain resistive formaldehyde sensors, is a binary nanohybrid of the nitrogen-doped onion-polyvinylpyrrolidone type nanocarbonic materials. The mass percentage of nanocarbon material in the sensitive layer varies between 80 and 90%. From the point of view of the detection principle, the resistance of the sensitive layer increases with the formaldehyde concentration level. The decrease in conductivity is explained by the fact that polar formaldehyde molecules interact coulombically with onion-type nanocarbon materials (p-type conduction), leading to the formation of a layer depleted in electric charge, disrupting the percolation channels. This situation leads to an increase in the electrical resistance of the sensitive material.



1) CNOs are obtained by thermal treatment at 1650 ºC of nanodiamond in helium atmosphere
2) fluorinated CNOs – CNOs treated in F_2 and Ar plasma F2 and Ar (volume mixture 1:6)
3) heating to 500 ºC in the NH_3 atmosphere of fluorinated onion-type defluorinated nanocarbon materials with vacancies in the structure occupied by the nitrogen atoms, resulting N-CNOs.



The structure of sensor with interdigitated electrodes

Sensing structure

The sensor substrate is made of Si/SiO_2 and has a size of 5 mm, the electrodes being made of gold. The width of the electrodes is about 200 microns, with a separation of 6 mm between them.
The formaldehyde monitoring capacity is investigated by applying a constant current between the two electrodes and measuring the voltage at different values of the formaldehyde concentration to which the sensitive layer is exposed, such as nanocarbon materials of the carbonic onion type doped with nitrogen - polyvinylpyrrolidone.

Sensor manufacturing

The mass percentage of nitrogen in the composition of onion-type nanocarbon materials doped with nitrogen varies between 5 and 10%.
Raw materials for the synthesis of the sensitive layer are: polyvinylpyrrolidone (PVP), onion-type nanocarbon materials doped with nitrogen. The solution of polyvinylpyrrolidone in water is prepared by dissolving 2 mg of polymer in 100 ml of ethanol, under magnetic stirring (2 h, at room temperature). Afterwards, 8 mg of onion-type nanocarbon materials doped with nitrogen are added to the previously prepared solution and the magnetic stirring is continued for 2 hours, at room temperature.
The obtained dispersion is deposited by the "drop casting" method on the Si/SiO_2 substrate with linear electrodes or interdigitated electrodes (after masking the contact area beforehand). The densification of the sensitive layer is carried out in the nitrogen atomosphere, for 120 minutes, at a temperature of 100 ^{0}C;

Advantages of the proposed sensing layer

- CNOs doped with nitrogen offers high specific surface/volume ratio, affinity for formaldehyde molecules as well as a variation in the resistance of the sensitive layer upon contact with them;
- polyvinylpyrrolidone is an effective dispersant for onion-type nanocarbon materials doped with nitrogen. Additionally, the gradual swelling of PVP has an effective contribution in the detection and monitoring of formaldehyde. Thus, the contact points between onion-type nanocarbon materials doped with nitrogen decrease, resulting in a gradual increase in resistance.- detection at room temperature;

Acknowledgments: Participation to Infoinvent 2023 is granted by project ID584/2021, 43PFE/30.12.2021, Excellence and Performance for Increasing the Institutional Capacity of RDI (ProExcellence), financed by the Ministry of Research, Innovation, and Digitization, and project CNFIS-FDI-2023-0048, Start-Inov: Research and Innovation as an interface for preparing a sustainable competitive environment, financed by the Romanian Ministry of Education.